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Analysis of Grain Production and Productivity in the People's Republic of China

by

Yisheng Si

A paper

submitted to the Department of Rural Economy

in partial fulfillment of the requirements for the degree of

Master of Agriculture

in Agricultural Economics

DEPARTMENT OF RURAL ECONOMY

EDMONTON, ALBERTA

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THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Department of Rural Economy, for acceptance, a paper entitled **Analysis of Grain Production and Productivity in the People's Republic of China** submitted by Yisheng Si in partial fulfilment of the requirements for the degree of Master of Agriculture in Agricultural Economics.

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Date April 15, 1991

Dedication

To my mother, Shufen Wang, and my father, Huichun Si (1921 - 1984) whose love and encouragement are being kept in my memory forever.

Abstract

Grain production is the foundation of economic development in most countries, especially in a big country like the People's Republic of China. Analysis of grain production and productivity can help understand how the past performance was, and provide useful information to develop grain policies and improve grain production. The purpose of this paper was to analyze historical trends, to decompose output growth and to analyze trends in total factor productivity (TFP) in Chinese grain production.

The compound growth rate of grain production was 3.02 percent per year for the period of 1949 - 1988. Grain yield grew at a rate of 3.27 percent, and grain area declined at a rate of 0.25 percent annually. From the decomposition analysis of the growth in grain production, the two most important contributions to the growth of grain production in value terms were that of price (58.76%) and yield (32.82%), which together exceeded 90 percent of the total contributions. Considering both the historical trend and the decomposition analysis, it is concluded that the growth potential of grain production mostly depends on the improvement of grain yields and the adjustment of price structures.

The physical output of five major grains grew at 3.05 percent from 1952 to 1986, and the aggregate input at 2.36 percent. Grain inputs were aggregated using Solow's geometric approach which is based on factor shares. Therefore, grain productivity, as measured by the index of TFP, increased by 0.69 percent annually.

After the Economic Reform in 1978, Chinese grain production increased at a faster rate than before. The growth rate of TFP in grain production was also higher in the post - Economic Reform period than in the pre - Economic Reform period. This indicates that the Economic Reform in China had considerable positive influence on grain production at least until the mid 1980s.

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Chapter 1 Introduction

1.1 Problem Definition

In a big country like China with a large population, scarce arable land, and a developing economy, the inadequacy of grain production and the associated food problem is an important issue. With economic development, the demand for grain increases, but increases in grain supply, since the mid-1980s, have slackened in China. The pressure of the grain problem continues to exist. It is considered by China that grain production is a basic foundation for developing the economy in China, especially for feeding over 1.1 billion people.

The past performance indicates overall improvement in Chinese grain production over four decades, especially after 1978 when the Economic Reform started. How many factors affect grain production and in what degree they affect grain production are very important to provide a useful assessment of the past performance and an understanding of the components of Chinese grain production. In this paper, the growth in grain production and productivity in the People's Republic of China is analyzed. Trends in grain production, decomposition of growth in grain production, and productivity analysis are covered.

1.2 Research Objectives and Significance

The general objective is to analyze production and productivity trends in grain production in Chinese agriculture. The specific research objectives include:

1) to describe and analyze historical trends in Chinese grain production;

2) to decompose the growth in Chinese grain production, using the statistical decomposition procedures originally developed by Minhas and Vaidyanathan

(1965);

3) to analyze trends in total factor productivity using procedures based on factor shares or geometric aggregation;

This analytical study can help in understanding the grain situation in China. The results may contribute to an increased awareness of trends in grain production and productivity and a greater appreciation how these might be improved in the People's Republic of China.

1.3 Organization of the Paper

There are six chapters in the paper. The problem definition, research objectives and significance of this study, and organization of the paper are covered in Chapter 1. The background of Chinese agriculture and grain production are described in Chapter 2. The trends in national and regional grain production in China are highlighted in Chapter 3. The decomposition of growth in Chinese grain production is studied in Chapter 4. Productivity performance in Chinese grain production is analyzed in Chapter 5. Conclusions and limitations of this thesis are provided in Chapter 6.

Chapter 2 Background of Chinese Agriculture and Grain Production

2.1 Land Resources

Of China's 9.6 million square kilometers of territory, 19 percent is desert, permafrost, glacier and mountains -- none of which can be used for agriculture. Seven percent of the land is occupied by cities, industries, mines and roads. The remaining 74 percent of the land has or can be used for agriculture, forestry, animal husbandry and fisheries (Wittwer, 1987, p. 36). It is said that China is a country with " a large territory with immense resources" (National Agriculture Statistics, 1985, p.8). It is true that China is the third largest country in the world, however, with such a huge population, the arable land per person is much less than the world average. The average total land area per capita in China is less than one hectare, which is only 30 percent of the world average (Wittwer, 1987, p. 36).

It is conservatively estimated that China has only 13 million hectares of land remaining unused for crop production, which are located chiefly in the areas of Heilongjiang and Xinjiang provinces. This would require a large investment to reclaim and becomes a significant constraint to expansion of land resources for agricultural development in China.

2.2 Water Resources

Water resources are the lifeline of Chinese agriculture (National Agriculture Statistics, 1984, p.9). Water resources are the most important natural resource base for a steady increase in agriculture production. Although total water resources are great in China, per capita water resources are relatively small. The total annual precipitation approximates 6,000 billion cubic meters, an average rainfall of only

630 millimeters and five percent of the world total. The annual river flow is 2,600 billion cubic meters, or only 2,700 cubic meters per person compared with an average of 10,930 cubic meters for the entire world (National Agriculture Statistics, 1984, p.9).

Water and land resources are very unevenly distributed among regions in China. Good soil seldom combines with good water resources (Wittwer, 1987 p.50), and they do not usually occur together within a region. The total annual flow or run-off of the Yangzi, the Pearl and other rivers in the southeastern coastal areas and southwestern China constitute 82 percent of the total. The arable land in these watersheds, however, constitutes only 38 percent of the total. By contrast, the run-off of the Huai River, the Hai River, and the Yellow River in northeastern and northwestern China constitutes only 18 percent of the total, while 62 percent of the arable land is in their drainage areas (Wittwer, 1987, p. 50-51). The situation is further complicated by frequent floods in the south, where water is abundant but land is scarce, and the droughts in the north, where good land is plentiful but water is limited.

In addition, rainfall in China varies greatly from year to year, and season to season. Rainfall for most parts in China is generally scarce in the winter and spring and abundant during summer and autumn.

Historically, the effective and efficient use of natural resources for agricultural production in China has been a serious problem. Although great achievements were made in water and soil conservation and on yield improvements, there exist a lot of problems. An exploding population, coupled with a weak material and technical

base for agricultural production, and improper use of natural resources through the 1950s, 1960s, and even through the 1970s, resulted in negative influence on the agricultural production base.

Generally speaking, abundant natural resources provide very good conditions for agricultural development in China. Due to a huge population, per capita resources are much lower than the world average. Therefore, increasing agricultural production with limited resources, and given a huge population, is a significant challenge for the Chinese.

2.3 Weather

The weather conditions are varied and complex because China covers vast ranges in latitude, longitude and altitude, and includes eight temperature zones. The eight temperature zones from north to south are the cold temperate zone, the temperate zone, the cold plateau, the warm temperate belt, the north subtropical zone, the middle tropical zone, the south tropical zone, and the tropical zone. Generally, accumulated temperatures or heat sums above 10^0c range from 1,6000^{0}c to 9,000^{0}c in China, and the frost-free period ranges from less than 100 days to the entire year free of frost (Wittwer, 1987, p37-38). The diversity and geographical variations of the agro-ecotypes in China may be the most unique in the world. Therefore, most types of plants from the torrid zone to the frigid zone can be grown in China. The various aqro-ecotypes provide good conditions for agricultural development in China.

Multiple cropping systems are quite common in China, especially in the southern parts. Anywhere from one to four crops per year are grown. The average index of multiple cropping in China as a whole in the 1980s was approximately 140

percent (Wittwer, 1987, p.37). This is an important reason why the Chinese have been able to produce so much grain on a limited arable land resource. Multiple cropping makes wise use of time and compensates for lack of space.

2.4 Overview

2.4.1 Historical Background

Before the founding of the People's Republic of China in 1949, China was a semi-feudal and semi-colonial society. The feudal society had lasted for thousands of years. Of the numerous explanations investigators have advanced for this phenomenon, one that has been generally acknowledged was the existence of a self-sufficient economy in the countryside. The basis of this economy was agriculture.

China is and has been a predominantly agrarian country throughout her history, in spite of her highly sophisticated civilization which is essentially urban in character. The share of rural population is estimated at about 80 percent of the total Chinese population. For such a big country, agriculture plays an important role in the general economy because agriculture is the principal form of production in China and can meet basic needs for people.

In the 1950's, China's traditional agrarian structure of small peasant farms on land, often owned by and leased from urban landlords, was changed: first by means of a land reform, then by collectivization in consecutive steps and finally by the formation of people's communes. Most of the early agricultural producers' cooperatives had gone through a period of poor management during their initial stage because of lack of experience in organizing collective production. With the formation of communes, decisions were made entirely by commune directors or

by a few commune cadres, and assignments were given on the spot every morning, without a regular production order. As a result, inputs were wasted, and there was resource inefficiency.

During the "Cultural Revolution" (1966-1976), China's countryside experienced considerable change in the operation of the people's communes. Agricultural production activities were developed at the smallest subunit of the commune, the small labour team. The production was led by the "Left" ideology of that era. Almost every small labour team paid little attention to effectiveness and efficiency, rather they focused only on production, and tried to be one of the model teams. The commune or the labour team whose yield was the highest would be awarded as an advanced commune or an advanced labour team. The "Dazhai[1] work point system" was introduced, completely replacing the prior set of production management systems established before this period.

People's Communes and production brigades in most areas of the country had to follow the example of Dazhai. With the method, the "Commune spot" was formed. That is, as long as a commune member worked in the field, his pay was equal to other's. The Dazhai method of appraising work points seriously stifled the commune members' enthusiasm for production. The negative influence of the "cultural revolution" was not checked until after the Third Plenary Session of the Eleventh Party Central Committee (October, 1978). The Third Plenary Session of the Eleventh Party Central Committee of the Communist

---

1 "Dazhai" was a model according to Dazhai's political criteria with whom commune members were compared in assigning work points through self-assessment and public discussions.

Party of China in late 1978 marked a great turning point in Chinese history and new starting point as China entered a period of major economic reform. As a result, remarkable changes have taken place in Chinese agriculture.

2.4.2 Production Responsibility System

The production responsibility system was adopted as a major measure to execute the economic reform in China. Wang (1985, p.8) states: "A production responsibility system usually refers to a managerial system under which the duties and rights of the production department, unit and individual in the process of production are clearly stipulated within an enterprise." At first, the production responsibility system was carried on in rural areas throughout the People's Republic of China. In the mid- 1950s, many agricultural cooperatives had instituted the contract system or the system of contracting jobs and fixing output quotas. These contracts were assigned to the production team or group as a unit. The contract system solved the problems of the rushed jobs and disorganization resulting from the practice of commune directors assigning jobs on the spot. However, this could not overcome the phenomenon of idleness and waste in production nor of irresponsible attitudes towards work because of the lack of a clear division of labour with clear responsibilities set for individual commune members within the production teams.

As a result of the influence of the "Left" ideology in the ten chaotic years of the "Cultural Revolution", these production responsibility systems were sabotaged. Every production unit, people's commune and production brigade,

had to follow the model of "Dazhai", namely the Dazhai method of appraising work points. Therefore, the farmer's enthusiasm for production was seriously damaged.

After the Third Plenary Session of the Eleventh Party Central committee in 1978, the responsibility system in agricultural production was restored and improved. It made big strides forward in terms of popularity, diversity of forms and effectiveness. However, because of the influence of the "Left" ideas over many years, there were still some problems to establish the production responsibility system. By June 1982, about 99 percent of the basic accounting units had established the responsibility system.

Many kinds of responsibility systems exist in agricultural production. There are perennial and seasonal responsibility systems, collective and individual responsibility systems, comprehensive and specialized production responsibility systems, and work and output responsibility systems. "At present, the most common forms of production responsibility system adopted in China's collective agricultural enterprises (production team and agricultural co-operatives) are various forms of the work and output responsibility systems related and unrelated to output" (Wang, 1985, p. 11).

Basically, these responsibility systems can be split into two responsibility systems: (1) the work responsibility system or the contract system for a given task; and (2) the output responsibility system, or the contract system for a fixed output.

2.5 Grain Regions

In China, rice and wheat are considered as "noble" or superior grains in contrast to corn, barley, sorghum and millet, often referred to as "coarse" grains.

In China, wherever rainfall is abundant or irrigation water is available, there is rice production. It extends from the southern border of Heinan island near 18^0 south latitude to Mohe County of Heilonghiang province at 53^0 north latitude. Rice cultivars grown in China are mainly of the paddy irrigated type. However, there are numerous upland cultivars suitable for places where there is insufficient water. Hand transplanting of paddy rice is almost universal. Growing seedlings for 2 - 3 weeks in small beds under plastic allows for equivalent earliness in maturity. It is also much more efficient than direct seeding in utilizing limited land and water resources.

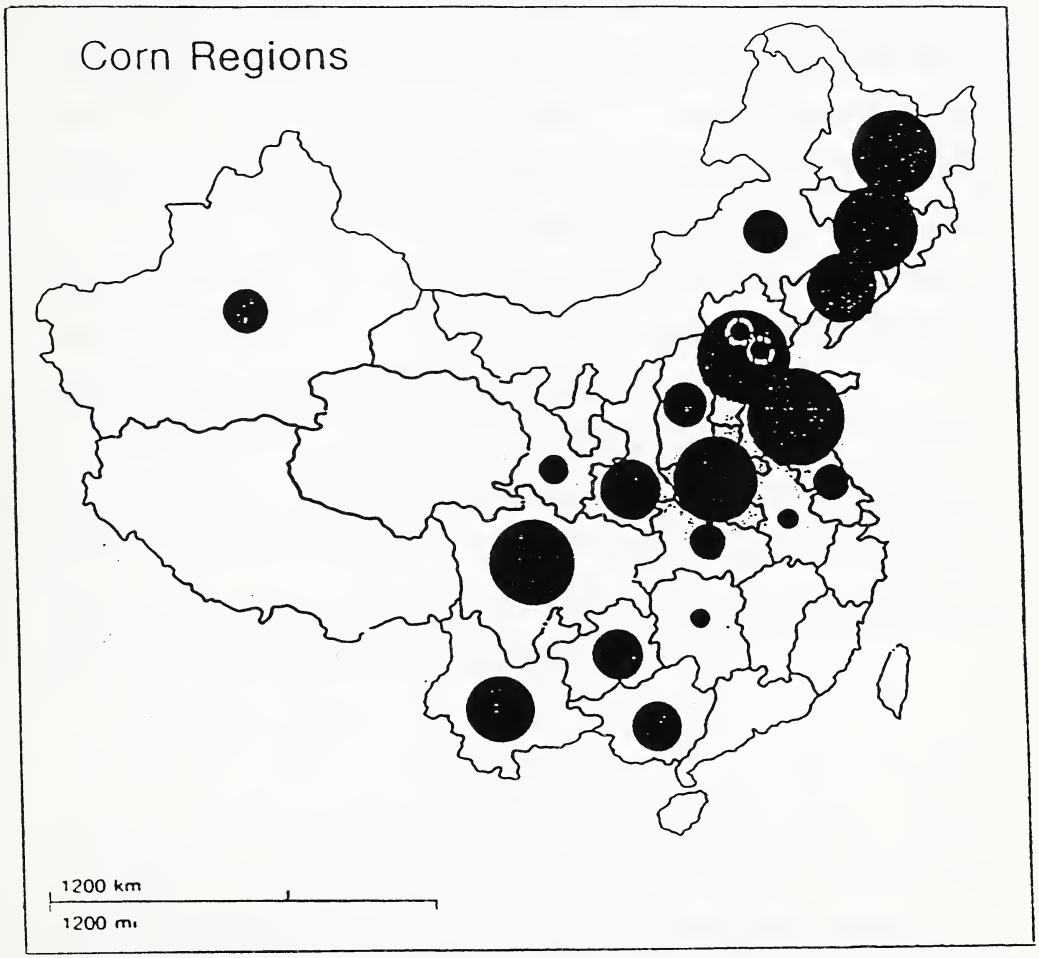
Wheat is produced in every province, autonomous region and municipality. There are two types of wheat, winter wheat and spring wheat. Winter wheat production predominates (85 percent) and extends from the 30th north latitude in the south to the 40th north latitude. Spring wheat is grown in the most southern and northern geographical extremities of China (see Figure 2.1).

There is a corn belt in China extending from Harbin in Heilongjiang province at the northeast to Kunming in Yunnan province of the southeast (see Figure 2.2). Soybeans are mainly grown in eight provinces: Heilongjiang, Henan, Shandong, Anhui, Jilin, Liaoning, Jiangsu and Hebei. Millet and sorghum are very widely produced in China, stretching from 32 to 50 degrees north latitude and from 108 to 130 degrees east longitude. As one of the oldest of crops, barley is cultivated almost every where in China. There are two types of potatoes: sweet potato and Irish potato. Both of them are grown extensively today in China.

Figure 2-1. The Wheat Regions of China

Source: "*Feeding A Billion*". Wittwer. 1987, P.160.

Figure 2-2. The Corn Belts of China



Source: "*Feeding A Billion*". Wittwer. 1987, P.172.

Chapter 3 Trends in Chinese Grain Production

3.1 Introduction

Even though grain production in some years decreased during the period from 1949 to 1989, the general trend of grain production was increasing. Between 1949 and 1984, the country's population doubled, but grain output increased four fold, so that yearly amount of grain per capita doubled from 200 to 400 kg. In that sense, China had basically solved her food problem. As a result of the Economic Reform in 1978, further achievement was made and the growth rate after the Economic Reform was greater than that before the Economic Reform. Nevertheless, the continuing problem of increasing grain production to meet the needs of China's huge population is a big challenge both today and in the future.

In this chapter the overall growth trend in Chinese grain production is analyzed. The national growth trend in grain production is discussed. Through analyzing the growth trend in grain production, many factors affecting grain production can be examined so that the study can help understand what major factors restrict grain production, and how to improve grain production.

The definition of grain in China is not the same as that in the western world. Grain means "foodgrain" in China. Besides rice, wheat, corn and coarse grains, soybean and tuber crops have also been included. In certain circumstances, soybean is considered as a cash crop. Usually, potatoes are converted to grain equivalent using the ratio of five tonne of potatoes equals one tonne of grain. Coarse grains are composed of millet, corn, sorghum, barley, buckwheat, oats, proso-millet, small beans, small green bean, broad beans, peas, and others.

3.2 Position of Specified Grain Crops in Total Grain Production

Among grain production in China, rice accounts for nearly 45 percent of the total, followed by wheat and corn (see Table 2-1). The so called "noble" grains, rice and wheat, have historically comprised 55 to 60 percent of total grain production, with "coarse" grains some 25 to 30 percent.

Table 3-1. Individual Crops as Percentage in Total Grain Production, China

	1957 MMT	%	1977 MMT	%	1987 MMT	%
All grains	195	100	285	100	402	100
Rice	87	45	129	45	174	43
Wheat	24	12	41	14	88	22
Coarse grains	52	27	86	30	100	25
(Corn)	(21)	(11)	(48)	(17)	(76)	(19)
Tubers	22	11	19	7	28	7
Soybeans	10	5	10	4	12	3

Sources: 1. Anthony Tang and Bruce Stone, "*Food Production in the People's Republic of China*." Research Report No. 15, International Food Policy Research institute, May 1980, PP. 157-158.

2. Estimation from *Chinese Statistics Yearbook*, 1987.

The percentage of rice in total grain production between the 1950s and 1980s did not change much, but both wheat and corn increased considerably in relative importance. Corn production increased rapidly in the 1970s, but it did not increase that much in the 1980s. While the relative share of wheat did not increase much during the 1950s, 1960s, and 1970s, it did increase rapidly in the 1980s. Tubers and soybean are relatively stable at 7 and 4 percent respectively. Others, including millet,

sorghum, barley, oats, peas, small beans and others, did not change between 1957 and 1977, but decreased rapidly in the 1980s. All of the above shows the importance of "noble" grains over "coarse" grains in China, and growth trends of increases in "noble" grains and decreases in non-corn "coarse" grains.

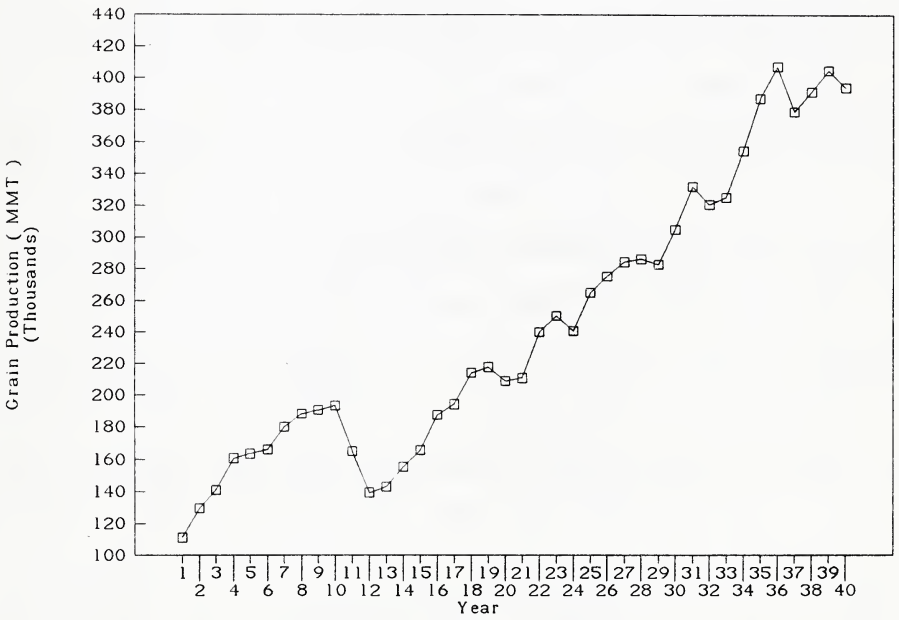
3.3 Trend of the National Grain Production

The growth trend in grain production has been relatively stable compared with other crops, such as cotton. However, because of technical changes, policy measures and social reform, grain production has also fluctuated from time to time. After China entered into a new historical stage in 1949, the economy recovered quickly from the old economic system. In the initial recovery period of 1949-1952, grain production increased quickly from 111.2 million tonnes to 160.6 million tonnes or just over 45 percent in three short years. This great change was partially attributable to the land reform during 1950-1952. The land reform in China promoted farmer's incentives to improve farming practices and management, to increase multiple cropping and to reclaim land. In 1953, China began its first five-year plan. Grain production reached a new peak of 193.5 million tonnes in 1958, a 73 percent increase in only ten years or a 6.3 percent annual growth since the beginning of the recovery period.

During the so-called Great Leap Forward (1958-1960), the Chinese government pressed industrialization of the rural areas on a broad basis. The failure of the Great Leap Forward policies was accompanied by a decline in grain production. In addition, natural disasters in the period of 1959-1961 frequently occurred as well. Grain production declined appreciably from 190.7 million tonnes in 1957 to 139.4 million tonnes in 1960. From 1961 to 1965, grain production

increased steadily and reached a new record of 194.5 million tonnes in 1965. In the period of the "Cultural Revolution" from 1966 to 1976, the increases in grain production were steady although there were three downward fluctuations in the years 1968, 1972 and 1977 (see Figure 3-1).

Figure 3-1. Growth in Grain Production, China 1949-88



Source: Chinese Statistic Bureau. *Chinese Statistic Bureau*, 1987.
Note: 1=1949, 2=1950, ... , 40=1988

Since 1978, Chinese grain production has increased much faster than before. In only seven years from 1978 to 1984, grain production increased about 103 million tonnes, which means about a 34 percent increase. In 1984, grain production reached

a peak of 407.3 million tonnes. After 1984, grain production decreased a bit, then increased at a relatively slower rate compared with that from 1978 to 1984. However, none of these years from 1985 to 1988 reached the record grain production. Therefore, there is concern both inside and outside of China that the impact of the reforms may have leveled off.

Further examination can be made through the information of grain area and grain yield. Grain area increased quickly from 1949, and steadily reached the highest record of 136.3 million hectares in 1956 in the entire Chinese agricultural history. Although grain area fluctuated from time to time due to the impact of policy changes, the changes in grain area are not as much as in grain production. The more important and interesting thing is that since the economic reform in 1978, grain area showed a decreasing trend, and in 1985 grain area reached the lowest point for the past 40 years of Chinese history. Data on grain yield is quite different from that of grain area. Grain yield increased from 1.01 tonne per hectare in 1949 to 1.52 tonne per hectare in 1958, a 50 percent increase in ten years. Since then grain yield decreased again due to the misguided policy of the Great Leap Forward period and frequent natural disasters. From the early 1960s, grain yield had begun to recover and increased steadily for about 20 years. Beginning with 1978, grain yield increased dramatically; it reached the historical record of 3.60 tonne per hectare in 1984, about a 45 percent increase relative to 1978 and about 58 percent relative to 1974. After 1984, grain yield did not increase much. On the contrary it decreased a small amount (see Table 3-1).

Table 3-2. Grain Production, Area and Yield in China, 1949-88

Year	Grain Production ('000 tonnes)	Grain Area ('000 hectares)	Grain Yield (Kg per hectare)
1949	111211	109959	1011
1950	129647	114406	1133
1951	140885	117769	1196
1952	160649	123979	1296
1953	163498	126637	1291
1954	166119	128995	1288
1955	180155	129839	1388
1956	188375	136339	1382
1957	190661	133633	1427
1958	193454	127613	1516
1959	165236	116023	1424
1960	139430	122429	1139
1961	143154	121433	1179
1962	155310	121621	1277
1963	165722	120741	1373
1964	187500	122103	1536
1965	194525	119627	1626
1966	214000	120988	1769
1967	217820	119230	1827
1968	209055	116157	1800
1969	210970	117604	1794
1970	239955	119267	2012
1971	250140	120846	2070
1972	240480	121209	1984
1973	264935	121156	2187
1974	275270	120976	2275
1975	284515	121062	2350
1976	286305	120743	2371
1977	282725	120400	2348
1978	304765	120587	2527
1979	332115	119263	2785
1980	320560	117243	2734
1981	325020	114958	2827
1982	354500	113463	3115
1983	387275	114047	3396
1984	407310	112884	3608
1985	379108	108845	3483
1986	391512	110933	3530
1987	404733	111220	3620
1988	394081	109910	3590

Sources: 1. Chinese Statistics Bureau, *Chinese Statistics Yearbook*, 1984, 1985, 1986 and 1987.
2. U. S. D. A., *Agricultural Statistics* in P. R. China.

There are some recent studies analyzing China's grain production. Barker, Sisler and Rose (1982) pointed out that a long term growth rate in grain production depends critically on the base year chosen. If the year from the recovery period of 1949-1952 (three year average) is selected as a base year, that would skew long term growth rates markedly. With that caret, they calculated annual growth rates for selected time periods as follows:

1949-1951 / 1955-1957	6.7 percent
1955-1957 / 1977-1979	2.4 percent
1952-1953 / 1977-1979	2.8 percent
1949-1951 / 1978-1980	3.3 percent

According to their calculation, the annual growth rate of grain output between the late 1950s and the late 1970s was about 2.4 percent, or slightly higher than the population growth rate.

Based on the study by Perkins and Yusuf (1978), the three year average between 1955-1957 was considered as a reliable base year for analyzing the growth trend in grain production. They compared these figures with those in 1978-1980 and found that grain output grew only slightly faster than the increase in population, at a rate of 2.25 percent a year. They discovered that much of the more impressive growth occurred in the mid-1960s and after 1977, and the substantial increase in 1978 and 1979 coincided with a sharp rise in grain prices. They found out that the 1955-1957 base was just before the disasters of the "Great Leap Forward", which led to a sharp decline in grain output in 1959-1961, and the recovery to earlier levels was not achieved until 1965. If 1964-1966 is used as a base, then the growth rate rises to 3.4 percent.

Carter and Zhong (1986) divided the 38 years of the People's Republic of China into five periods:

1949-1952	The Post-Liberation period.
1953-1957	The First Five Year Plan period.
1958-1965	The Great Leap Forward and following recovery period.
1966-1978	The Cultural Revolution period.
1979-1986	The Economic Reform period.

The annual grain growth rates in these five periods are listed, respectively, at 13.0 percent, 3.5 percent, 0.2 percent, 3.5 percent and 3.2 percent. They point out that the initial period was not relevant because it was in the recovery period, and the third period might be ruled out because of the policy mistakes during the Great Leap Forward in 1958. Therefore, the long-run growth trend for total grain production between 1952 and 1978 might be arbitrarily taken as 3.5 percent per year. This is slightly higher than the 3.2 percent growth rate in grain production calculated in the economic reform period by Carter and Zheng.

All of the above studies directly or indirectly show that the base year chosen is very critical in analyzing the long-run growth trend in grain production. If the year 1949 is selected as the base year, the long run growth rate will be overestimated because grain production increased dramatically in the recovery period of 1949-1952. If selecting a year from 1955 to 1957, the growth rate might be underestimated because grain production did not increase as much as usual due to the misdirected "Great Leap Forward" policy and frequent natural disasters in the following years.

It seems more appropriate to divide the 40 year of post - revolution Chinese history into several periods to analyze the growth trend in grain production rather

than just to calculate only one long-run growth rate. A research paper by the Commercial Economic Research Institute of the Ministry of Commerce and leading economists in China, such as Xu Dixing, Yu Guangyuan, Liu Suinian and Wu Qungan, divided the Chinese evaluation after 1949 into six periods:

1949-1952	Post-Liberation Economic recovery period
1953-1957	The First Five Year Plan period
1958-1960	The Great Leap Forward period
1961-1965	National economy readjustment period
1966-1976	The Cultural Revolution period
1977-	The Economic Reform period

The above periods are divided according to political events in Chinese history. However, the turning points between periods may not be appropriate to draw a dividing line for an economic analysis.

This thesis divides the 40 year Chinese history after 1949 into five periods which is quite similar to what Carter and Zhong did. In order to focus on long - run growth trends and simplify the situation, the 1958-1960 and 1961-1965 periods are combined into one because the 1958-1960 period had many natural disasters and a large scale mistake caused by policy failure, while the following period was a recovery period. It is also reasonable to prolong the cultural revolution period until the end of 1977 because the economic reform started in 1978.

In this paper, besides the analysis of growth trend of total grain production, the growth of individual grain crops, and growth of grain area and yield are examined as well. All of the above growth rates are calculated based on the following approach.

The exponential curve $Y = a * b^t$ is used to represent a trend with constant rate of increase or decrease. In logarithmic form it becomes:

$$\text{Log } Y = \text{Log } a + t \text{ Log } b \qquad (3 - 1)$$

where Y = the variable in year t; and

t = time (1949=1, 1950=2, ..., 1988=40).

By calculating the anti-log of the estimated coefficient on time in the above equation, the growth rate can be estimated by G = (b-1) * 100, expressed in percentage terms.

The growth rates in grain production over various periods have varied widely from 1.52 percent to 12.6 percent (see Table 3-2). The growth rates in the early two periods are quite high, 12.6 percent and 4.43 percent respectively, while in the period of 1956-1965, the growth rate is quite small. The average rate during 1953-1988 is about 3 percent. The overall growth rate in grain production in the period of 1949-88 was 3.02 percent per year. Examining the growth rates before the Economic Reform (1952-1977), and after the Economic reform (1978-1988), the latter (2.89 %) is greater than the former (2.46 %).

Table 3-3. Annual Compound Growth Rates in Grain Production, P.R.C. Various Periods, 1949 - 1988

Period	Total	Rice	Wheat	Corn	Sorghum	Millet	Potatoes	Soybeans	Barley	Oats
									(Unit:	%)
1949-52	12.60	11.83	10.39	15.66	8.99	9.54	17.83	22.5	11.26	11.29
1953-57	4.43	5.61	5.92	8.30	-6.39	-4.95	8.34	1.45	2.39	2.38
1958-65	1.52	2.73	0.08	2.82	0.92	-2.27	-1.69	-3.71	4.52	4.52
1966-77	3.29	3.39	6.00	6.20	1.73	-1.92	2.69	-1.62	-3.23	-3.23
1978-88	2.89	2.63	5.70	3.02	-3.68	-2.74	-1.10	5.11	-1.99	-1.73
1949-88	3.02	3.12	4.81	4.90	-0.69	-1.35	2.52	0.53	0.24	0.27
1949-77	2.72	2.98	3.56	4.60	-0.16	-1.39	3.77	-0.44	0.96	0.96

Source: Estimation.

Table 3-4. Annual Compound Growth Rates in Grain Yield, P.R.C. Various Periods, 1949 - 1988

Period	Total	Rice	Wheat	Corn	Sorghum	Millet	Potatoes	Soybeans
							(Unit: %)	
1949-52	8.32	8.24	5.66	11.64	10.81	13.80	9.66	10.10
1953-57	2.74	1.38	1.43	2.49	0.57	-1.84	3.88	1.32
1958-65	1.81	3.41	0.56	-0.27	-0.64	-1.73	1.94	-2.41
1966-77	3.10	1.42	4.49	4.08	5.56	2.46	2.61	0.69
1978-88	3.83	3.39	5.65	3.55	2.64	2.31	1.72	4.01
1949-88	3.27	2.52	4.24	3.55	3.41	1.92	2.61	1.83
1949-77	2.80	1.98	3.15	3.04	2.80	1.34	2.93	1.56

Source: Estimation

Table 3-5. Annual Compound Growth Rates in Grain Area, P.R.C. Various Periods, 1949 - 1988

Period	Total	Rice	Wheat	Corn	Sorghum	Millet	Potatoes	Soybeans	Barley	Oats
									(Unit: %)	
1949-52	3.97	3.32	4.45	3.59	7.44	-1.65	3.73	6.79	6.78	11.96
1953-57	1.64	4.16	1.56	5.66	4.29	-6.91	-3.18	0.39	0.38	0.12
1958-65	-0.28	-0.65	-0.47	3.10	-3.56	1.56	-0.56	0.04	0.04	-0.74
1966-77	1.89	1.94	1.45	2.04	0.08	-3.63	-4.27	-3.88	-3.88	-2.29
1978-88	-0.93	-0.73	-0.01	-0.45	-1.15	-6.36	-4.93	-2.87	-2.90	1.25
1949-88	-0.25	0.59	0.54	1.31	-0.28	-3.98	-3.20	-2.39	-2.39	-1.17
1949-77	-0.08	0.98	0.40	1.51	0.82	-2.89	-2.69	-1.63	-4.63	-1.83

Source: Estimation.

Table 3-3 shows annual compound growth rates in grain area and Table 3-4 shows annual compound growth rates in grain yield in various periods for China. It seems that before 1977, the trend of grain area increased except during the period between 1958 and 1965. Meanwhile, the trend of grain area decreased after 1978. Table 3-4 clearly presents, in the early three periods, the decline of the growth rates in grain yield, 8.32 percent in 1949-1952, 2.74 percent in 1953-1957 and 1.81 percent in 1958-1965. Then the growth rates in grain yield increased in the following periods, 3.1 percent and 3.83 percent respectively. The growth rate of grain yield after the

Economic Reform is greater than that before the Economic Reform. Most growth in grain yield occurred in the initial phase of the post - Economic Reform period (from 1978 to 1984). Grain yields from 1984 to 1988 were relatively stable in the 3500 to 3600 per hectare range.

The production of rice, wheat and corn are the main components of grain production. Production increases or decreases in these grains provide the bulk of changes in total production. Other grain crops occupy a small portion of grain, therefore, their production has a much smaller effect on total grain production. The growth of grain production depends on grain area and grain yield. It is impossible to increase grain area rapidly because arable land in China is very limited and the net cultivated area has been declining for quite some time. Especially after 1978, the overemphasis on cash crops caused a decrease in multiple cropping in grain in some local regions, and this led to a decline in grain area. The result in Table 3-4 shows that after 1978, the growth rate in grain area is negative 0.93 percent per year. The declining rate after 1978 is 0.68 percent higher than that before 1978. Even though grain area declined after 1978, total grain production still increased. The accelerated growth in grain production has been solely due to the increased grain yields. Therefore, the growth potential of grain production mostly depends on the increase of grain yields.

From the above analysis, the change in grain production and the growth of grain production have had a close relationship with the major change of political events, the policy changes accompanying these policy changes, and social reforms. These political events are usually the signs of changes of grain production. The Land Reform (1950-1952) brought a big agricultural achievement in Chinese history. The

growth rate in grain production in the period of 1949-1952 was 12.6 percent, a very high rate in past due to recovery but also in considerable part due to reforming land institutions. The Great Leap Forward (1958-1960) caused declines in grain production of 1.52 percent. During the Economic Reform period, though the growth rate in grain production was not very high at 2.89 percent, total grain production reached historical records of 407.3 million tonnes in 1984 and 407.45 million tonnes in 1989 (China Today, April 1990).

Chapter 4 Decomposition of the Growth in Grain Production

4.1 Literature

Decomposing the growth trends in grain production is a type of quantitative analysis in agricultural growth. By decomposing the growth into different components, the growth in grain production can be easily examined. Such analysis of agricultural growth makes it possible to estimate the separate effects of changes in area, yield, crop pattern, and the interaction between each other.

In 1965, Minhas and Vaidyanathan pioneered the component analysis of the growth in grain production. Their study quantifies the components of growth in grain production. There are two approaches to decomposition: the additive scheme and the multiplicative scheme.

4.1.1 Additive Decomposition Methods

At first, the growth in the additive scheme was decomposed into four physical factors (Minhas, 1965): area, yield, and crop pattern as well as an interaction between the latter two. Price enters this model solely as a weighting device. Notational representation of this model is as follows:

$$Q_t = A_t \sum_i P_i \alpha_{it} Y_{it}$$

$$Q_0 = A_0 \sum_i P_i \alpha_{i0} Y_{i0}$$

where t = time period;

i = crop;

Q_t = gross value of total grain production in period t;

Q_0 = gross value of total grain production in base year;

A_t = the area harvested of grain crops in period t;

A_0 = the area harvested of grain crops in base year;

P_i = the weighted price of the ith crop;

a_{it} = the proportion of the grain crop area devoted to the ith crop during period t;

a_{i0} = the proportion of the grain crop area devoted to the ith crop during the base year;

Y_{it} = the yield of the ith crop in period t;

Y_{i0} = the yield of the ith crop in the base year.

Therefore, $Q_t - Q_0 = A_t \sum_i P_i a_{it} Y_{it} - A_0 \sum_i P_i a_{i0} Y_{i0}$.

Given the basic formulation, the growth in grain production can be decomposed into four components (Minhas, 1965):

$$Q_t - Q_0 = (A_t - A_0) \sum_i P_i a_{i0} Y_{i0} + A_0 \sum_i P_i a_{i0} (Y_{it} - Y_{i0})$$
$$+ A_0 \sum_i P_i Y_{i0} (a_{it} - a_{i0}) + A_0 \sum_i P_i (Y_{it} - Y_{i0})(a_{it} - a_{i0}) \qquad 4-1$$

If the crop pattern and yield are held constant, then the first term on the right of the equation represents the effect of a change in the area harvested. Assuming the area and crop pattern remain unchanged, the second term stands for the effect of the yield component of the growth. The third term represents the effect of the change in proportion of total area in grain devoted to specific crops assuming area and yield are constant. The last term indicates the interaction effect between yield and crop pattern. A positive crop mix effect represents that the crop pattern has changed with a crop having a high gross value per acre

expanding relative to other crops. Patrick and Swanson (1978) used this additive scheme to decompose the growth in grain production in the North Central states in the United States of America from 1937 to 1977.

Later Minhas (1966) expanded the above four factor model in the framework of a seven factor additive model which was subsequently used by Misra(1971), and Sondhi and Singh(1975). In a seven factor additive model, the pure effects of yield and crop pattern are reduced because there are two new interactions, one between area and yield and the other between area and crop pattern. The four factor model's interaction element was split into two by Minhas - yield and crop pattern interaction with area fixed at base year level and a three factor interaction between changes in area, yield and crop pattern. Notional representation of the expanded model is as follows (Minhas, 1966):

$$
\begin{aligned}
Q_t - Q_0 = {} & (A_t - A_0) \sum_i P_i a_{i0} Y_{i0} + A_0 \sum_i P_i a_{it} (Y_{it} - Y_{i0}) \\
& + A_0 \sum_i P_i Y_{i0} (a_{it} - a_{i0}) + A_0 \sum_i P_i (Y_{it} - Y_{i0})(a_{it} - a_{i0}) \\
& + (A_t - A_0) \sum_i P_i (a_{it} - a_{i0}) Y_{i0} \\
& + (A_t - A_0) \sum_i P_i a_{i0} (Y_{it} - Y_{i0}) \\
& + (A_t - A_0) \sum_i P_i (Y_{it} - Y_{i0})(a_{it} - a_{i0}) \qquad 4-2
\end{aligned}
$$

The first three terms on the right side of this equation are respectively pure effect of area, yield and crop pattern. The fourth, fifth and sixth terms are respectively the interaction between yield and crop pattern, area and crop

pattern, and area and yield. These effects signify the influence of any of the two factors over the other in bringing the growth change. The last term is the three factor interaction between changes in area, yield and crop pattern.

Sagar (1979) put price structure into the additive decomposition models. He indicates that because of the changes in tastes and preferences or technical or physical constraints on specific crops, prices may change over time. It is necessary to include price structure in the growth analysis in grain production. Sagar defined price structure as "the set of current year prices such that the overall average price of agricultural commodities remains at a constant level. While at same time, it incorporates the movements in prices relative to each other." The model with price structure developed by Sagar is as follows:

$$I_t - I_0 = \sum_i \alpha_{it} Y_{it} P_{it} - \sum_i \alpha_{i0} P_{i0} Y_{i0} \qquad 4-3$$

where I_t is the productivity of a cropped grain area, as determined by cropping pattern, yield, and price impacts, in value terms in the t^{th} year. Then the decomposition model will be:

$$\begin{aligned} I_t - I_0 = & \sum_i \alpha_{i0} Y_{i0} (P_{it} - P_{i0}) + \sum_i \alpha_{i0} P_{i0} (Y_{it} - Y_{i0}) \\ & + \sum_i Y_{i0} P_{i0} (\alpha_{it} - \alpha_{i0}) + \sum_i \alpha_{i0} (P_{it} - P_{i0}) (Y_{it} - Y_{i0}) \\ & + \sum_i Y_{i0} P_{i0} (\alpha_{it} - \alpha_{i0}) (P_{it} - P_{i0}) + \sum_i P_{i0} (\alpha_{it} - \alpha_{i0}) (Y_{it} - Y_{i0}) \\ & + \sum_i (\alpha_{it} - \alpha_{i0}) (Y_{it} - Y_{i0}) (P_{it} - P_{i0}) \qquad 4-4 \end{aligned}$$

Substituting 4-3 into 4-4, the additive model incorporating changes in relative prices can be obtained as

$$Q_t - Q_0 = A_t I_t - A_0 I_0$$

$$Q_t - Q_0 = (A_t - A_0) I_t - A_t (I_t - I_0)$$

$$\begin{aligned} Q_t - Q_0 = {} & (A_t - A_0) \sum_i a_{i0} Y_{i0} P_{i0} + A_t \sum_i a_{i0} Y_{i0} (P_{it} - P_{i0}) \\ & + A_t \sum_i a_{i0} P_{i0} (Y_{it} - Y_{i0}) + A_t \sum_i Y_{i0} P_{i0} (a_{it} - a_{i0}) \\ & + A_t \sum_i a_{a\,i0} (Y_{it} - Y_{i0})(P_{it} - P_{i0}) \\ & + A_t \sum_i Y_{i0} (a_{it} - a_{i0})(P_{it} - P_{i0}) \\ & + A_t \sum_i P_{i0} (a_{it} - a_{i0})(Y_{it} - Y_{i0}) \\ & + A_t \sum_i (a_{it} - a_{i0})(Y_{it} - Y_{i0})(P_{it} - P_{i0}) \end{aligned} \qquad 4-5$$

The first four terms on the right of the equation (4-5) are respectively the pure effects of area, price, yield and crop pattern. The latter three terms are respectively the interaction between yield and price, crop pattern and price, and crop pattern and yield. The final term is the interaction between crop pattern, yield and price.

4.1.2 Multiplicative Decomposition Methods

The multiplicative scheme was first used by Parikh (March 1966) and Dayal (December 1966). The model they used is:

$$\frac{A_t \sum_i a_{it} Y_{it} P_{i0}}{A_0 \sum_i a_{i0} Y_{it} P_{i0}} = \frac{A_t}{A_0} \frac{\sum_i a_{it} Y_{it} P_{i0}}{\sum_i a_{i0} Y_{it} P_{i0}} \frac{\sum_i a_{i0} Y_{it} P_{i0}}{\sum_i a_{i0} Y_{i0} P_{i0}} \qquad 4-6$$

The model expresses the index number of output as a multiple, respectively, of the index numbers of area, change in crop pattern and change in crop yields. The growth rate of agricultural output can be obtained through fitting an exponential time trend to each time series of index numbers and summing these respective growth rates:

$$g = g_A + g_a + g_Y \qquad 4-7$$

where g, g_A, g_a and g_Y are growth rates, respectively, of gross agricultural output, gross cropped area, crop pattern and yield.

Parikh's model introduces a residual component in order to do away with one to one correspondence between growth in crop area and its production. From (4-7), he developed the growth rate with a residual component as follows:

$$g = wg_A + (1-w)g_A + g_a + g_Y \qquad 4-8$$

where w is the weight assigned to the growth rate of area, and w is obtained by regressing $\text{Log}(A_t \sum a_{i0} Y_{it} P_{i0} / A_0 \sum a_{i0} Y_{i0} P_{i0})$ on $\text{Log}(A_t/A_0)$. Parikh indicates the real contribution of area and productivity should be:

$$GY(\Re) = g_Y + (1-w)g_Y$$

$$g_A(\Re) = g_A - (1-w)g_A = wg_A$$

"Conceptually, (1-w)g_A is the same as the interaction effect between gross area and gross productivity of Vidya Sagar's scheme" (Sagar 1980, p. 52). Sagar indicated that w in Parikh's regression equations contains not only the interaction effect but also the effect of factors influencing yield such as weather, irrigation

and fertilizers. In fact, the problem of a weather component is partially eliminated by taking wider time points for the computation of growth. Therefore, "the manner in which w is computed by Parikh raises doubt on the validity of his estimates" (Sagar 1980, p.53).

The decomposition model used by Parikh and Dayal is not conceptually clear. Minhas (1966) states that:

> *It evaluates the crop pattern effect at final year yields. One is interested in knowing the impact of a given crop pattern change if the base year yields and prices prevailed.*

Minhas developed the multiplicative scheme as an improvement over Parikh-Dayal's version. He split Q_t/Q_0, the ratio of final and base year production, as follows:

$$\frac{Q_t}{Q_0} = \frac{A_t \sum_i P_c Y_{it} a_{it}}{A_0 \sum_i P_c Y_{i0} a_{i0}}$$

where P_c is the constant price

$$\frac{Q_t}{Q_0} = \frac{A_t}{A_0} \frac{\sum_i P_c Y_{it} a_{i0}}{\sum_i P_c Y_{i0} a_{i0}} \frac{\sum_i P_c Y_{i0} a_{it}}{\sum_i P_c Y_{i0} a_{i0}} \frac{\sum_i P_c Y_{it} a_{it}}{\sum_i P_c Y_{it} a_{i0}} \frac{\sum_i P_c Y_{i0} a_{i0}}{\sum_i P_c Y_{i0} a_{it}} \qquad 4-9$$

After the crop pattern is evaluated at base year, the residual component is produced. The residual is a ratio of the product of t period productivity and base period productivity to the product of t period productivities obtained by changing crop pattern and by growth in crop yields respectively. It is the joint effect of the two components net of their individual effects. This is the same as the interaction between the crop pattern and yield components.

Sagar indicated that the price effect on the growth of grain production was ignored in the decomposition models, and he did adopt the price structure into his additive scheme decomposition model. However, no empirical work has been done in the direction in which a price variable was included in the multiplicative scheme decomposition model. The grain production in value terms is much affected by the price structure. Changes in price play an important role in the growth of grain production. In addition, to include a price variable can provide meaningful insight into the decomposition models and is useful for policy making. Adopting the multiplicative decomposition model makes more sense than in the additive scheme because "the multiplicative scheme explains its compound rate in terms of the component growth rates, while the additive scheme decomposes absolute increase of grain production and explains its linear growth rate of grain production" (Sagar, 1980. p.49).

This chapter focuses on a multiplicative scheme decomposition model, extending it to include the price structure, to decompose the growth of grain production in China.

4.2 Model and Data

Applying the variables and notation mentioned earlier, the model extension used in this chapter is:

$$\frac{Q_t}{Q_0} = \frac{A_t \sum_i P_c Y_{it} a_{it}}{A_0 \sum_i P_c Y_{i0} a_{i0}}$$

$$\frac{Q_t}{Q_0} = \frac{A_t}{A_0} \frac{\sum_i P_{i0} Y_{it} a_{i0}}{\sum_i P_{i0} Y_{i0} a_{i0}} \frac{\sum_i P_{i0} Y_{i0} a_{it}}{\sum_i P_{i0} Y_{i0} a_{i0}} \frac{\sum_i P_{it} Y_{i0} a_{i0}}{\sum_i P_{i0} Y_{i0} a_{i0}}$$

$$\frac{\sum_i P_{it} Y_{it} a_{it} \sum_i P_{i0} Y_{i0} a_{i0} \sum_i P_{i0} Y_{i0} a_{i0}}{\sum_i P_{i0} Y_{i0} a_{it} \sum_i P_{i0} Y_{it} a_{i0} \sum_i P_{it} Y_{i0} a_{i0}} \qquad 4-10$$

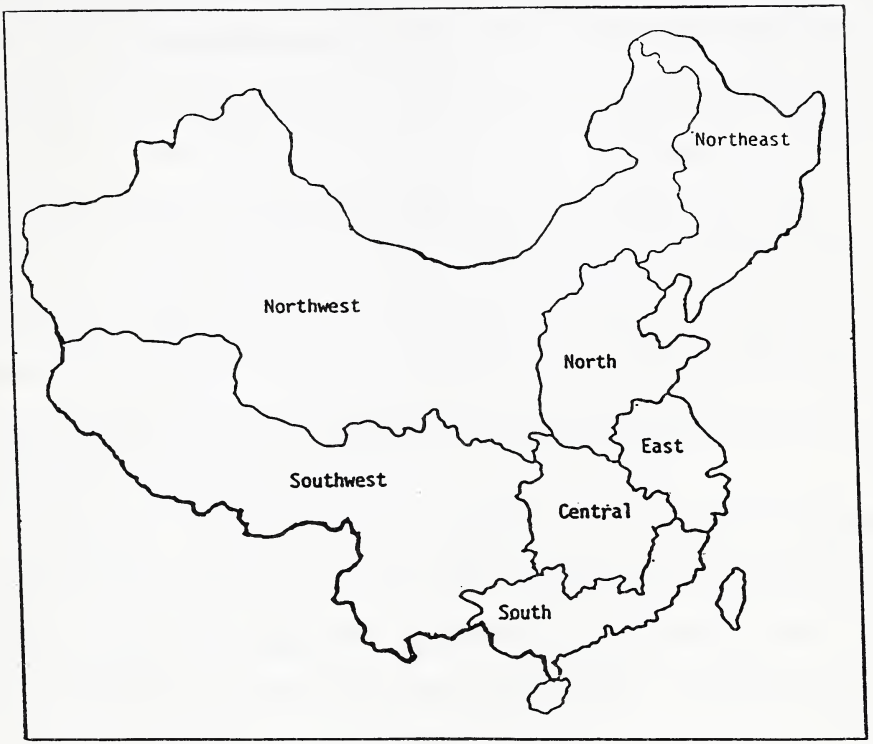
The first four terms on the right hand side of equation 4-10 are respectively area effect, yield effect, crop pattern effect, and price effect. The last term is a key interaction term among area, yield, crop pattern, and price. Given the results of previous studies, such an interaction effect is expected to be quite small. Other possible interaction terms in this four factor model have been suppressed to make the model tractable.

The model is primarily a descriptive technique useful for quantifying changes: it is not an analytical technique for explaining the sources of these changes. For example, the effect of yield increase can be quantified, but the model cannot attribute it specifically to improved varieties, increased use of fertilizer, or other changes which have occurred.

Grain price information for China is extremely difficult to locate. There is no direct price information available either from Chinese official sources or the USDA. However, there exists price indexes from 1950 to 1986 for five major grains (Price and Trade Statistics in China, 1987) -- for rice, wheat, corn, sorghum and soybeans (Appendix I). The price index cannot be directly applied to decomposition analysis because it only reflects the growth trend of price of an individual grain crop, and does not reflect relative prices in the base period. From the Chinese Statistics

Yearbook (1987), exchange price ratios between respective agricultural products and industrial product - salt, can be derived. The exchange price ratios were calculated based upon purchasing prices for agricultural products and industrial products. Multiplying each grain price index and the exchange price ratio, the new comparable, time series price information (not actual price, but a price proxy) can be formed. Detailed time series information on yield and area for sorghum is not available. Consequently, only four major crops covering 73 to 87 percent (estimated from Chinese Statistics Yearbook 1987) are covered in this study. If three year or five year averages of all the relevant variables are used, it is preferred because random fluctuations in the level of production and productivity can be ironed out. Unfortunately, all regional data available are from 1979-1985, as a result, averaging is not feasible at the regional level and annual time series are used in the component analysis. Estimation at the national level was done with both unaveraged and three-year moving average figures. According to Crook (USDA, 1987), China is divided into seven regions (see Figure 4-1). They are Northeast, North, Northwest, East, Central, South and Southwest. Northeast region includes Heilongjiang, Liaoning and Jilin provinces. North region includes Shandong, Hebei, Beijing, Tianjin, Henan and Shanxi provinces. Northwest region includes Shaanxi, Gansu, Nei Monggol, Ningxia, Xinjiang and Qinghai provinces. East region includes Zhejiang, Jiangsu, Shanghai and Anhui provinces. Central region includes Hubei, Hunan, and Jiangxi provinces. South region includes Grangdong, Guangxi and Fujian provinces. Southwest region includes Sichuan, Guizhou, Yunnan and Xizang provinces.

Figure 4-1. Map of the People's Republic of China



Source: It is adopted from *Ststistics Yearbook, 1983*. Bejing, China, 1984. P.3.

4.3 Results and Interpretation

The decomposition results at the national level are based on three various periods, the whole period of 1949 - 1986, the pre-Economic Reform period of 1949-1978, and the post-Economic Reform period of 1979-1986, which are shown in Table 4-1. In the period of 1949 - 1986, the total growth of aggregate agricultural production in "value" terms was 9.08 percent per year. The biggest contribution to this output growth, at 58.76 percent, was due to the changes in the relative price structure, and the least contribution of output growth, only 0.47 percent, was due to the changes of crop pattern. The contribution of yield growth was large too, 32.82 percent, and the contribution of area growth was relatively small, 5.36 percent. The interaction effect among the changes in yield, crop pattern, and price structure was 2.59 percent of the output growth.

In the pre - Economic Reform period, the overall growth in aggregate agricultural grain production in "value" terms approximated 8.2 percent per year. The contribution of the price effect reached 61.45 percent and the contribution of the yield effect was about 28.9 percent of the output growth. The other components of output growth are 6.34 percent due to the changes in area, 1.49 percent from changes in crop pattern, and 1.78 percent interaction effect among the three variables.

After the Economic Reform, the overall growth in grain production "value" increased to 11.2 percent per year. The big difference in this period is that the contribution of area was negative, -6.24 percent, and the yield share of the grain

production growth increased to 48.98 percent. The shares of price structure changes and crop pattern change of the grain production growth are respectively 51.57 percent and 0.07 percent. The residual component is 5.62 percent.

Table 4 - 1. Decomposition Growth Shares of Grain Production, China and its Regions

Unit:%

	Total	Area	Yield	Crop pattern	Price	Inter - action
Northeast	100	0.27	33.60	2.07	60.69	3.36
North	100	-5.77	54.32	0.34	52.25	-1.13
Northwest	100	-6.31	52.12	0.92	55.14	-1.86
East	100	6.69	45.53	-2.62	50.08	0.33
Central	100	-6.03	49.17	-0.10	57.23	-0.28
South	100	-35.21	47.92	5.47	82.82	-1.00
Southwest	100	-8.28	47.66	4.30	56.93	-0.61
China						
1949-86	100	5.36	32.82	0.47	58.76	2.59
1949-78	100	6.34	28.94	1.49	61.45	1.78
1979-86	100	-6.24	48.98	0.07	51.57	5.62
1949-51 to 1984-86*	100	6.85	37.66	-9.41	56.54	8.36

Source: Estimations.
Note: *Estimation is based on the three year average time series data.

The three year average of all relevant variables have been used for the whole time series in the period of 1949-1951 to 1984-1986. Only one big difference from the results with annual time series is that crop pattern contribution was - 9.4 percent rather than a positive 0.47 percent. Other components were not much different from the results with annual time series. They are 6.85 percent for the area effect, 37.66 percent for the yield effect, 56.54 percent for the price effect, and 8.36 percent for the interaction effect.

The results from the above national component analysis of the growth of grain production can be summed up in the following points:

1). The contribution of price structure to the growth of grain output was the biggest component, which is about 55 percent. This result indicates that the price factor is playing a very important role in grain production in China.

2). The yield effect accounted for about one third of the growth in grain production. Unlike price structure which plays an indirect role in the growth of grain production, the yield effect directly influences grain production. It is the second biggest factor in the growth of grain production.

3). The area effect is still playing a positive role in grain production. However, the area effect is negative after the Economic Reform Period, - 6.24 percent, while it is positive before the period. This result shows the declining contribution in the growth of harvested area to the growth of grain production.

4). Both the crop pattern effect and the interaction effect in the growth of grain production are positive, but typically small. The positive crop pattern effect indicates a shift from low gross value per hectare to high gross value crops. The positive contribution of yield effect, crop pattern effect, and price effect lead to the positive interaction effect of the growth of grain production.

5). Comparing the two periods before and after the Economic Reform, the price contribution to the growth decreased about 10 percentage points, from 61.45 percent to 51.57 percent. On the other hand, the yield contribution increased about 20 percentage points, from 28.94 percent to 48.98 percent. This is largely because the Production Responsibility System had been introduced. A farmer's profit was dependent upon his production which could primarily be increased only through

yield-increasing technology. Farm management had been improved quickly. The crop pattern contribution decreased from 1.49 to 0.07 percent and the interaction effect increased from 1.78 to 5.62 percent. This result was due to the introduction of free market mechanisms. The ability of the state to adjust price decreased as a result; the crop pattern effect decreased, while the residual component, or interaction effect, increased.

The components of growth in grain production for the regional level are presented in Table 4 - 1 for the period of 1979 - 1985. The overall growth rates of grain production "value" at the regional level are very high in this particular time period especially when compared with growth rates historically since 1949. They range from 7.11 percent to 12.73 percent. The growth components varied among these regions. The area contribution to the growth of grain output was negative in five regions, North (-5.77), Northwest (-6.31), Central (-6.03), and South (-35.21), and Southwest (-8.28). The contributions of area growth to the growth of grain production were positive but very small in the Northeast (0.27 percent) and somewhat relatively larger in the East (6.69 percent). All regions experienced positive, large contributions from both the price effect and the yield effect. The price effect accounted for 50.08 percent to 82.82 percent, and the yield effect accounted for 33.6 percent to 49.17 percent of the growth in grain production across the seven regions. The crop pattern effect was positive in the Northeast, North, Northwest, South and Southwest, and negative in the East and Central regions. The residual component was negative in the North, Northwest, Central, South and Southwest, and positive in the Northeast and East regions.

The results from the above regional component analysis of the growth in grain production in the period of the Economic Reform can be summed up in the following points:

1). The Northeast and East regions had potential land to be developed. For example, the Three Rivers Plain in the Northeast region had a lot of land with too much moisture, on which a crop could not be planted without a large investment in reclamation. The contribution of area to growth is positive in these two regions. The North, Northwest, Central and Southwest regions, in contrast, did not have much land to be developed. In fact, arable land in these regions for growing crops was even reduced. Therefore, these regions showed negative contribution of area to the growth of grain production. The East region is a special case. In this region, land for farming is quite limited, most of it is covered by semi-arid grass plains and desert. Due to the policy changes in the Economic Reform Period, more land was used for animal husbandry, farming land was reduced, and the contribution of the area effect was -3.5 percent.

2). The contribution of price effect and yield effect for the respective regions experienced similar patterns compared with the results at the national level in the same period. The contribution of the yield effect to foodgrain growth was dependent on the constraints of resources. The constraint levels in different regions were different, such as climate conditions and soil conditions. Consequently, the yield contribution to growth varied from region to region. The price effect was quite different compared with the yield effect. It is mostly dependent on the government control. After freer market mechanisms had been introduced since 1978, grain prices become more flexible than those before the Reform period. However, the

centralized economy was still playing an important role in China. In addition, grain prices administered by different regions were different. Even in different provinces, they were not the same. Therefore, the price contribution to regional grain production growth was underlain by a more complex process than these results might suggest. However, the average prices for the whole nation did reflect the general trend of grain prices at the regional level. The results highlight the important role of price structure as a determinant of growth in the "value" of regional grain production.

3). The Northeast, North, Northwest, South and Southwest regions adjusted to shift lower gross value crop land to higher gross value crop land, making positive contributions to the growth of grain output. On the other hand, the East and Central regions could not adjust to shift crops or could not adjust by themselves due to the Chinese government policy, therefore, the contribution of crop pattern was negative. The residual component shows the interaction effect among price effect, yield effect, and crop pattern effect. Northeast and East regions' contributions are positive, the remaining regions are negative in this attribute.

Overall, the price contribution and the yield contribution occupied most of the growth of grain production. Most potential to increase grain production in China lies in the adjustment of the price structure through government policy, and through improving the yields by improving science and technology.

The negative contribution of area effect shows that farm land to be developed is quite limited, except in some outlying regions, where potential exists to reclaim new farm land. Therefore, increasing grain production can not rely on an increase of the productive land base.

Adjusting crop pattern in time can help to improve grain production. Through forecasting the gross value of different crops, decisions can be made to shift to a higher gross value crop so that the contribution of crop pattern can be improved.

Chapter 5 Measurement and Analysis of Grain Productivity

In previous chapters, the discussion focused on the growth trend of grain output in China, and decomposition analysis of the relative roles of area, yield, cropping pattern, and price as influences on Chinese grain production. In this chapter, measurement and analysis of productivity in Chinese grain production are discussed.

5.1 Measurement of Productivity

5.1.1 Partial Factor Productivity and Total Factor Productivity

Productivity is a technical efficiency measure based on quantity of output in relation to quantity of input. If productivity is expressed in terms of output per unit of a single input, then such a measure is called partial factor productivity (PFP). If productivity is measured as the ratio of aggregate output to aggregate input, then such a measure is called total factor productivity (TFP). PFP is seldom a satisfactory measure of productivity because it attributes all of the output to a single input and ignores the role of other inputs, therefore, it is incomplete, and often misleading. Land productivity, for example, does not exactly measure productivity because productivity increase can be achieved by increasing labor, capital, or fertilizer. However, "the partial productivity measures are most useful where the supply of a particular factor is relatively inelastic and that represents a serious constraint on the growth of output" (Hayami and Ruttan, 1978). In the densely populated countries, such as China, where lack of land is a serious constraint on growth, land productivity is very important.

TFP is an essential measure of productivity (Christensen, 1975) because, by definition, the total factor productivity measure reflects the effect of all factor

inputs in the production process. Although PFP may a useful index of productivity on occasion, TFP is the most complete and, for most purposes, the most satisfactory measure of productivity. Therefore, the main discussion in the chapter will focus on total factor productivity.

5.1.2 Index Number Approach for Measuring Productivity

There are three major indices used in aggregation in the measurement of productivity: the Laspeyres index, the Geometric index and the Divisia-related index.

5.1.2.1 The Laspeyres Index

The Laspeyres quantity index is constructed using base period prices as weights. It can be written as:

$$Q_t = \frac{\sum P_{i0} X_{it}}{\sum P_{i0} X_{i0}} \qquad (5-1)$$

where Q_t is the aggregate output (or input);

P_{i0} is the price of base period 0 for the i^{th} crop (or i^{th} input);

P_{it} is the price of period t for the i^{th} crop (or i^{th} input);

X_{i0} is the quantity of base period 0 for i^{th} crop (or i^{th} input); and

X_{it} is the quantity of period t for the i^{th} crop (or i^{th} input).

In similar vein, but using base period quantities as weights, the Laspeyres price index can be expressed as:

$$q_t = \frac{\sum P_{it} X_{i0}}{\sum P_{i0} X_{i0}} \qquad (5-2)$$

where q_t is the output (or input) price index.

The Laspeyres index is widely used in the literature. This is because the Laspeyres index is a simple way to aggregate either outputs or inputs and hence to measure productivity. Since prices are held constant at their base period levels, the Laspeyres input quantity index, for example, purports to tell how much of the change in value of total input resulted from changes in physical input quantities. Quantity data for subsequent periods are required to construct the Laspeyres indexes, once base period prices and quantities are known.

The Laspeyres index requires a linear production function (Christensen 1975, Diewert 1975). This implies that all factors are perfect substitutes in the production process.

As with the practical difficulty of calculating a growth rate of grain production, the base period chosen is critical to the Laspeyres index construction. The poorer the base period chosen, the greater the overestimate or underestimate of the index number in a later period.

5.1.2.2 Geometric Index

This index, made famous by Solow in his pioneering efforts in growth accounting from 1957 on, is based on the Cobb-Douglas production function, and uses factor shares as weights for measuring productivity.

The Cobb-Douglas production function can be expressed as:

$$Q_t = A_t K_t^{\alpha} L_t^{\beta} \qquad (5-3)$$

where Q_t is the real output at period t;

A_t is the index of technology (TFP) in period t;

K_t is the index of capital in period t;

L_t is the index of labor in period t; and

α , β are respectively capital's factor share and labor's factor share.

Here, for simplicity, only two inputs are used in the function. The function can be expanded for more inputs. Since K and L are indexes, weighted respectively by α and β, the Cobb-Douglas production function exactly represents a geometric index of inputs (Domar 1961).

5.1.2.3 The Divisia Index

Divisia-related indexes began being used in productivity analysis in the late 1960's and early 1970's. The continuous version of the Divisia index, following Christensen (1975), can be written as:

$$\frac{Q_t}{Q_0} = \exp\left\{ \int \sum W_{it} \left(\frac{\dot{X}_{it}}{X_{it}} \right) \right\} \qquad (5-4)$$

where $$W_{it} = \frac{P_{it} X_{it}}{\sum P_{it} X_{it}}.$$

P_{it} is the price of period t for the i^{th} crop (or i^{th} input);

X_{it} is the quantity of period t for the i^{th} crop (or i^{th} input);

$\dot{X}_{it}$ is the change of output quantity (or input quantity) over time.

W_{it} may be regarded as the share of the i^{th} factor input in total cost or the share of the i^{th} output in total output value.

The Divisia index has become a preferred index to other indexes because it is associated with less restrictive, flexible form production technology. Because the Divisia index uses prices from both the base period and the comparison period, it is more data intensive to construct. For empirical analysis, discrete approximations of the Divisia indexes are most widely used in current research, the most common of which is the weighted log-change index:

$$\log\left(\frac{Q_t}{Q_{t-1}}\right) = \sum \bar{w}_i \log\left(\frac{Q_{it}}{Q_{i,t-1}}\right) \qquad (5-5)$$

where $\bar{w}_i = \frac{(w_{it} + w_{i,t-1})}{2}$

This index is called the Tornqvist approximation to the Divisia index or the Tornqvist-Theil index.

5.1.2.4 Comparison of Indexes for Measuring Productivity

The common indexes used for measuring productivity, as indicated, are the Laspeyres index approach, the Divisia index approach and the geometric index approach.

The Laspeyres indexes are widely used because they are easy to understand and construct. However, there are some limitations to this approach. First of all, the Laspeyres index requires a linear production function, which does not correspond to the real world. In other words, inputs have to be perfect substitutes in the production process. Secondly, constant price information at the base period can not tell how production is affected by prices of outputs and inputs in the following periods after the base period.

The Divisia index approach is preferred in recent research because the approach has the following related advantages: first, the Tornqvist approximation to the Divisia index exactly corresponds to the translog production function (Christensen, 1975), which does not involve a linear production function and perfect input substitution; second, the flexible weight procedure can recognize changes of input cost over time, therefore, input substitution; third, the Divisia index approach, which uses prices in both base period and the comparison periods, allows one to examine production change with respect to the price changes in inputs and outputs compared with the base period.

There exist constraints for the geometric index approach. First, addition of all factor shares must be unity. This implies that the geometric index rules out the possibility of complementary relations between inputs in the production process. Second, there is a bias problem due to changing relative prices; and third, factor shares represent a given state of technology, thus factor shares can not exactly reflect the technology changes. Although the approach has limitations, if factor shares are calculated year by year, the limitations will be minimized.

Through the discussion, the Divisia index approach is a preferred method to measure productivity. Unfortunately, due to the lack of price information, particularly input price information, the Divisia index approach can not be used in this study. The Laspeyres index approach has too many limitations. As a result, the geometric index approach is used in this study.

5.2 Survey of Previous Chinese Productivity Studies

Among western studies on Chinese productivity, the famous one was Tang's study (1980). The author did extensive work on data collection which made his work quite valuable. He made a projection of China's grain production and consumption for the 1977-2000 period. Four inputs used in his study were labor, land, capital and current inputs. By assuming factor shares and using Solow's framework, total factor productivity was estimated to decline over the 1952 to 1980 period at a rate of 0.65 percent per year. In other words, the technology change or productivity in Chinese grain production showed a decreasing trend.

Wong (1989) compared agricultural productivity in China and India. The author applied Solow's approach to measure total factor productivity. The factor shares for China are assumed as the estimated production elasticities from an estimated agricultural metaproduction function for centrally planned countries: 0.155 for labor, 0.042 for land, 0.239 for fertilizer, 0.173 for machinery, and 0.391 for livestock. The agricultural productivity decreased in the 1960's and 1970's and increased at an annual growth rate of 4.59 percent for the 1978 - 1983 period.

In Li's study (1989) based on statistical data for 1953 - 1984, productivity decreased steadily from 1953 to 1978 and rose slowly in the 1978 - 1984 period. A Cobb-Douglas production function was estimated to find factor shares: 0.19 for capital and -0.28 for labor. The conclusion is that 80 percent of the growth in output can be ascribed to technological progress. Li also examined the capital and labor partial productivity. Capital productivity decreased mildly in the 1953-1978 period and increased mildly in the 1978 - 1984 period, while labor productivity decreased greatly in the 1953 - 1978 period and grew markedly in the 1978-1984 period. Based

on these results, Li concluded that "increase in the capital input played an important role in raising output, and reduction in labor input did not affect the output due to the excess labor which exists in much of rural China. Increasing the capital input and reducing the labor input is an important source of TFP growth" (Li, 1990).

Fan (1990) for the first time analyzed productivity growth in China's agriculture at the regional level in the 1965-1986 period. In his study, he estimated the production elasticities for five inputs: labor, land, machinery, capital and livestock for every year. This avoided the problems inherent in Solow's framework: a bias problem due to changes in relative prices and the given state of technology. The results show that all regions except the Northwest had positive growth rates of total factor productivity in this time period. In addition, much of the growth in agricultural productivity was attributed to a consequence of an important series of institutional changes and reforms. As far as inputs are concerned, traditional inputs were still important but decreased, while modern inputs became more and more important in Chinese agriculture.

In a very recently published article by Lin (1990), Chinese agricultural TFP was discussed. He indicated that Tang's work was extended by Wen (1989) to cover the years up to 1988, and many of the time series Tang derived from the scattered fragments were replaced by Wen with official data made available to the public in the years after the publication of Tang's work. By comparison, both Tang's estimates and Wen's estimates show the same pattern of changes in TFP. Lin also examined how much the TFP results might be changed by using two alternative sets of factor shares, one set proposed by Wiens (1982) (.35 for labor, .36 for land, .09 for capital, and .20 for current input), and the other the estimates of Hayami and Ruttan (1985,

p.151) (.45 for labor, .10 for land, .30 for capital, and .15 for fertilizer). He stated that "these various estimates of total factor productivity show that in terms of absolute magnitude, different factor shares and the methods give rise to somewhat different estimations; nevertheless, in terms of the pattern of changes, the results are identical" (Lin 1990, p. 1246).

5.3 Total Factor Productivity Analysis

5.3.1 Methodology - Solow Growth Accounting Framework

Index numbers have been combined with the production function to measure productivity in recent decades by economic researchers. The Solow growth accounting framework, which combines the geometric index with the Cobb-Douglas production function, has been widely used historically and continues to be the most realistic alternative in LDCs.

Assuming the production function with the special case of neutral technical change and a elasticity of substitution of unity, then, the aggregate Cobb-Douglas production function in the case of two inputs, capital and labor, can be written as:

$$Q = f(K, L; t) = A_t K^{\alpha} L^{\beta} \qquad (5-6)$$

where Q = physical units of output;

K, L = physical units of capital and labor;

α, β = factor shares of capital and labor;

t = time variable which can represent technical change;

A_t = the multiplicative factor measuring cumulated effect of shifts over time.

Through differentiation and substitution, the following equation can be obtained (Solow, 1957):

$$\frac{\dot{Q}}{Q} = \frac{\dot{A}_t}{A_t} + \alpha\frac{\dot{K}}{K} + \beta\frac{\dot{L}}{L} \qquad (5-7)$$

$\frac{\dot{A}_t}{A}$ is a residual which represents technical change. The residual is defined as the change in total factor productivity. The production function will change corresponding to the change of technical change over time.

5.3.2 Data

Foodgrain output and input data are abtained by following closely to Tang's methodology.

5.3.2.1 Aggregate Grain Output (Table 5 - 1)

Grain production, displayed in Table 5-1, is composed of the following crops: rice, wheat, soybean, coarse grain[2] and potatoes[3]. Grain output is aggregated using 1952 constant prices. The resultant aggregate grain output index, essentially a Laspeyres quantity index, is shown in Table 5-3.

5.3.2.2 Aggregate inputs (Table 5 - 2)

The inputs used in Chinese grain production are derived under the simplifying assumption that all inputs used in crop production are devoted to foodgrain production. The land input is measured by adjusting the gross sown area by an irrigation factor using Tang's (1984) methodology. Sown area

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2 Coarse grain includes corn, sorghum, oats, barley and millet.

3 Potatoes are converted at a ratio of 5 to 1 to grain.

TABLE 5 - 1. GRAIN PRODUCTION, CHINA, 1952 - 1988

YEAR	RICE	WHEAT	COARSE GRAIN	POTATOES	SOYBEAN (Unit:	T. GRAIN 1000 tonne)
1949	48645	13810	31919	7876	5085	107335
1950	55100	14495	38095	9912	7440	125042
1951	60555	17230	38621	11200	8630	136236
1952	68425	18125	46000	13064	9520	155134
1953	71270	18280	44700	13328	9930	157508
1954	70850	23335	43274	13584	9080	160123
1955	78025	22965	48132	15120	9120	173362
1956	82480	24800	47646	17480	10240	182646
1957	86775	23640	45766	17536	10050	183767
1958	80850	22585	47571	26184	8670	185860
1959	69365	22180	39249	19056	8760	158610
1960	59730	22170	29589	16280	6390	134159
1961	53640	14250	43507	17384	6210	134991
1962	62985	16665	42083	18760	6510	147003
1963	73765	18475	41439	17112	6910	157701
1964	83000	20840	46528	20130	7870	178368
1965	87720	25220	47037	19860	6140	185977
1966	95390	25280	53487	22530	8270	204957
1967	93685	28485	56155	22430	8270	209025
1968	94530	27455	49580	22290	8040	201895
1969	95065	27285	50219	24120	7630	204319
1970	109990	29185	58340	26680	8710	232905
1971	115205	32575	61618	25070	8610	243078
1972	113355	35985	54135	24520	6450	234445
1973	121735	35225	62102	31560	8370	258992
1974	123905	40865	68263	28240	7470	268743
1975	125560	45310	71999	28570	7240	278679
1976	125810	50385	70203	26660	6640	279698
1977	128565	41075	70230	29670	7260	276800
1978	136930	53840	78647	31740	7565	308722
1979	143750	62730	82403	28460	7460	324803
1980	139910	55210	82372	28730	7940	314162
1981	143955	59640	79470	25970	9325	318360
1982	161595	68470	81819	26680	9030	347594
1983	168865	81390	91628	29245	9760	380888
1984	178255	87815	96222	28475	9695	400462
1985	168569	85805	82915	26036	10050	373375
1986	172224	90040	87070	25337	11614	386285
1987	173930	87720	93770	27820	12184	395424
1988	169110	85430	94170	26970	11645	387325

Source: 1. Chinese Statistics Bureau, *Chinese Statistics Yearbook*, various years.

2. U. S. D. A., *Agricultural Statistics in China, 1949-85*, 1986.

TABLE 5-2. GRAIN PRODUCTION INPUTS, CHINA, 1952 - 1986

Year	Adjusted Land (ha)	Labor Force	Machinery '000 horse Power	Draft Animal '000 head	Manu. Fert. MMT	Chem. Fert. MMT
1952	8764.2	26080	250	51420	11.98	0.078
1953	8992.5	26176	420	54790	12.54	0.157
1954	9183.0	26590	540	57240	13.14	0.186
1955	9272.6	27247	720	55710	13.11	0.248
1956	9889.3	27135	1260	54740	13.14	0.311
1957	9592.3	27413	1650	53680	16.31	0.373
1958	9206.1	25620	3420	49920	15.55	0.563
1959	8448.5	24750	5470	46600	15.25	0.527
1960	8890.6	23600	8010	41240	13.57	0.658
1961	8839.3	23725	9110	38180	12.98	0.466
1962	8869.4	25450	10290	40180	13.83	0.630
1963	8832.5	26473	11480	40330	15.29	0.988
1964	8945.1	25974	13210	41520	16.32	1.182
1965	8801.5	26983	14940	43220	19.54	1.942
1966	8917.8	27805	17840	44857	20.83	2.773
1967	8826.2	28597	20740	46976	21.14	3.003
1968	8646.9	29486	23640	48006	21.18	2.232
1969	8768.9	30370	26540	48262	21.20	3.000
1970	8905.4	31327	29440	49350	22.60	3.383
1971	9036.2	32257	41300	49900	24.18	3.665
1972	9086.0	33125	53160	51450	24.76	4.228
1973	9108.0	33829	65030	51400	24.89	5.162
1974	9121.6	34470	80630	51910	25.13	4.858
1975	9152.9	34943	101680	51220	25.76	5.369
1976	9153.3	35351	117330	50420	25.81	5.828
1977	9152.2	35689	139520	49790	25.89	6.448
1978	9163.3	39803	159754	50230	26.26	8.840
1979	9075.9	39286	181906	50290	26.94	10.863
1980	8938.4	40149	200486	50880	28.26	12.694
1981	8778.2	40790	213185	54710	28.25	13.349
1982	8668.6	40307	225890	58333	28.98	15.134
1983	8719.2	38558	245032	61250	29.19	16.598
1984	8636.9	30251	265573	64032	29.86	17.398
1985	8357.2	26492	284337	66464	31.22	17.758
1986	8501.2	22891	312032	69465	31.95	19.306

Sources: 1. Chinese Statistics Bureau, *Chinese Statistics Yearbook*, various years.

2. U.S.D.A., *Agricultural Statistics in China, 1949-85*, 1986.

already includes the multiple cropped land. There is, therefore, no need to adjust sown area for multiple cropping. Through the irrigation adjustment, a single year effective area for growing crops is estimated.

The labor force for foodgrain production is derived by assuming the size of the labor force changes with the age group from which most workers are drawn (15-64), rather than the total Chinese population. It is measured in terms of the number of persons at the end of the year.

Both values of machinery equipment and draft animals are counted as the capital input. Machinery input is measured in terms of total horsepower of tractors and irrigation equipment at the end of each year. The value of machinery input is estimated by multiplying total horsepower of machinery equipment by a proxy for the price of a horsepower unit -- the weighted 1952 draft animal prices.

Fertilizer input consists of chemical fertilizer and manurial fertilizer. They are added together by calculating the effective nutrient content for both of them.

Each input series was indexed in terms of 1952 = 100. Inputs were aggregated by multiplying each input by its factor share. Recently, Lin (1990) examined the resultant changes of estimation by employing different alternative sets of factor shares including Tang's (1984), Wiens' (1982) and Hayami and Ruttan's (1985). Lin stated that the results showed different estimations in terms of absolute magnitude and different factor shares,

however, in terms of the pattern of changes, the results are identical. As a result, Tang's set of factor shares (1984) was used in this study, 0.50 for labor, 0.10 for land, 0.15 for capital and 0.25 for current inputs such as fertilizer.

5.4 Results and Conclusion

The total factor productivity index can be estimated by dividing the aggregate output index by the aggregate input index. The results are shown in the Table 5-3.

The growth rate of TFP in China's foodgrain productivity in the 1952-86 period is positive at 0.69 percent[4] rather than negative as shown in some earlier western studies (for example, Tang's study over 1952-77). During the 1952-77 period, our estimated growth rate in productivity is 0.37 percent, and 3.42 percent in the 1978-86 period. The discrepancy between Tang's negative productivity growth rate over 1952 to 1977 and our low positive result is probably due to Tang's more complete input coverage and to the fact that some input series have been improved since the time of his work.

The growth rate of the labor index shows a very interesting result. In the 1952-77 sub-period, the annual growth rate of labor is 1.44 percent, while in the later 1978-86 sub-period, the annual growth rate is - 6.68 percent. But in the 1952-86 period, the annual growth rate is 1.11 percent per year. A major shortcoming in constructing the labor input series, which may bias our and previous results, is that no one has yet derived an "effective" labor input which has been adjusted for disquised unemployment. In all three periods, land growth had negative growth rates, -0.13 percent for the 1952-86 period per year, -0.04 percent for the 1952-77 period per

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4 The growth rates reflected in this section are compound annual growth rates.

TABLE 5-3 INDEXES OF AGGREGATE OUTPUT, MAJOR INPUTS, AGGREGATE INPUT AND TOTAL FACTOR PRODUCTIVITY (TFP), CHINESE GRAIN PRODUCTION, 1952-86 (1952=100) AND RELATED GROWTH RATES (PERCENT)

YEAR	LABOR INDEX	LAND INDEX	CAPITAL INDEX	FERTIL INDEX	OUTPUT INDEX	INPUT INDEX	TFP INDEX
1952	100	100	100	100	100	100	100
1953	100	103	108	106	101	102	99
1954	102	105	114	111	104	105	99
1955	104	106	105	111	112	106	106
1956	104	113	104	112	119	107	111
1957	105	109	137	139	119	114	104
1958	98	105	131	134	122	109	112
1959	95	96	121	131	104	103	101
1960	90	101	99	118	89	98	90
1961	91	101	94	112	88	97	91
1962	98	101	111	120	96	103	93
1963	102	101	130	135	102	109	93
1964	100	102	143	145	115	111	104
1965	103	100	154	179	121	119	101
1966	107	102	172	196	133	125	106
1967	110	101	176	201	136	128	107
1968	113	99	173	194	131	128	103
1969	116	100	172	201	133	131	102
1970	120	102	194	216	151	137	110
1971	124	103	229	231	157	145	108
1972	127	104	248	241	152	150	101
1973	130	104	257	250	169	154	110
1974	132	104	273	249	175	157	112
1975	134	104	302	259	182	162	112
1976	136	104	318	263	183	165	111
1977	137	104	341	269	180	169	107
1978	153	105	365	292	203	183	111
1979	151	104	396	314	213	188	114
1980	154	102	406	340	206	194	106
1981	156	100	415	346	208	197	106
1982	155	99	432	367	227	200	114
1983	148	99	450	380	251	201	125
1984	116	99	474	393	264	189	140
1985	102	95	506	407	247	186	132
1986	88	97	538	426	255	186	138
1952-86	1.11	-0.13	5.40	4.40	3.05	2.36	0.69
1952-77	1.44	-0.04	4.90	4.30	2.55	2.18	0.37
1978-86	-6.68	-2.74	4.48	4.40	3.44	0.03	3.42

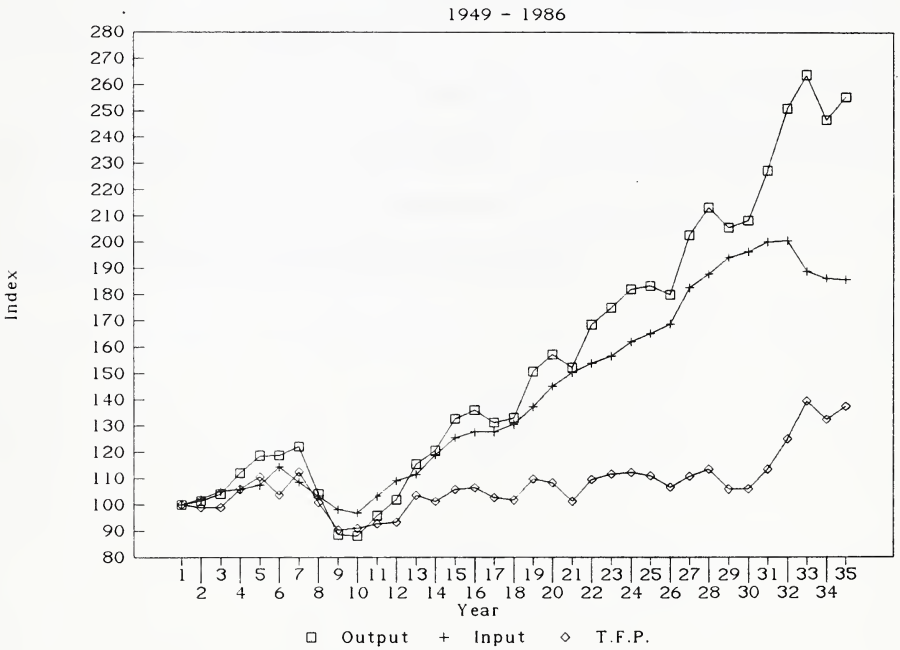
Sources: Estimations.

Note: The factor shares used in aggregating the individual input indexes into the aggregate input index were: 0.50 for labor, 0.10 for land, 0.15 for capital, and 0.25 for fertilizer.

year, and -1.08 percent for 1978-86 per year. Both capital input and fertilizer input grew at a relatively rapid rate, about 5 percent for capital and 4.4 percent for fertilizer per year.

Foodgrain output, input and TFP indexes are depicted graphically in Figure 5-1, for the period of 1952-86.

Figure 5-1. Ouput, Input and TFP Index



The diagram shows not only the growth trends of output, input, and TFP, but also the fluctuations of output, input, and TFP during these periods. In the early 1960's, for example, the grain output and input decreased due to the natural disasters and adverse policies of the Great Leap Forward period. It is shown that the growth

patterns of output, input, and TFP are similar in the diagram. In addition, the growth pattern of TFP in our results is generally similar to that recently reported by Lin (1990).

In conclusion, total factor productivity in Chinese grain production had positive growth rates with the highest growth in the 1978-86 period. Both capital input and fertilizer input grew steadily. But land input decreased in the 1978-86 period at -1.082 percent. Labor input increased in the 1952-77 period and decreased dramatically in the 1978-86 period.

From all of the above, it is summarized that after 1978, overall productivity in grain production in China improved quickly. Although land input and labor input decreased in the 1978-86 period while grain output still grew quickly, it is shown that land productivity and labor productivity increased.

Chapter 6 Conclusions and Implications

This chapter provides a brief summary of the major conclusions from the various analyses of Chinese grain production and productivity. In addition, the limitations of the study are discussed.

6.1 Conclusions

Chinese agricultural development during 1949 - 1988 was divided into five periods (Chapter 3). Annual compound growth rates of grain production, grain yield, and grain area in these five periods and the whole 40 year period were estimated. The overall growth trend in Chinese grain production was increasing at a rate of 3.02 percent per year during 1949 to 1988. Grain yield grew at 3.27 percent annually, and grain area at -0.25 percent. The annual compound growth rates in the pre-Economic Reform period were also estimated. Both annual growth rates of grain production and grain yield were greater in the post - Economic Reform period than in the pre - Economic Reform period prior to 1978. But, the declining trend in grain area was greater in the post - Economic Reform period than in the pre - Economic Reform period.

The multiplicative scheme extended decomposition model was used in this paper (Chapter 4). The decomposition of growth in grain production was estimated not only at the national level, but also at the regional level. From the estimated results, price and yield contributions to the growth in grain production were at least 90 percent for all various periods, the price contribution being about 60 percentage points and the yield contribution about 30 percentage points. Comparing the pre - Economic Reform period and the post - Economic Reform period, the price

contribution decreased 10 percentage points, the yield contribution increased 20 percent points, the area contribution decreased about 12 percentage points, and the remaining two, the crop pattern and interaction effects, showed no major big change. The results showed that while grain area contribution decreased, yield contribution increased and price contribution decreased. The decomposition at the regional level was estimated in the period of 1979 - 1986, which the years for data was available. Price and yield were also the biggest contributions to the growth in grain production, and had similar magnitudes of contributions to those at the national level. Although other components showed different signs (+,-) of contributions, they together had small contributions for all regions except the South region in which the area contribution was - 35 percent. Obviously, price and yield were the two most important components contributing to grain growth at the regional level as well. To increase grain production, the two most important things are adjustment of price structure and improvements of crop yield.

Through examining the growth in grain production and the decomposition of the growth in grain production in the pre - Economic Reform period and the post - Economic Reform period, it is found that the Economic Reform had a considerable positive influence on grain production. Although grain area decreased, the degree of decrease in grain area was smaller than the degree of increase in grain yield in the post - Economic period than the pre - Economic period, resulting in greater growth in grain production since 1978. Even though the area contribution to growth declined, the yield contribution increased, and the price contribution remained a large share. Therefore, the increase in grain production did not slow down due to the decrease in the area contribution, but was greater.

The Solow growth accounting framework was adopted to analyze total factor productivity in Chinese grain production. By using Tang's methodology, a grain input index, output index and TFP index were computed. The growth rate of TFP in Chinese grain production grew at 0.688 percent per year in the period of 1952 - 86. Labor, capital, and fertilizer grew at 1.11 percent, 5.40 percent, and 4.40 percent per year respectively, but land decreased at 0.13 percent. Comparing the pre - Economic Reform period with the post - Economic Reform period, the growth of TFP in our calculations increased 3 percentage points. The results further indicate that there was a considerable positive influence of the economic and institutional reforms associated with the introduction of the household responsibility systems in 1978 on Chinese production and productivity.

6.2 Limitations

1). Only eight years time series data for regional level analysis was not a long enough time series to provide fully conclusive results in the decomposition of the growth in regional grain production. In addition, the base year chosen has an important influence on the estimated results. Therefore, although the decomposition analysis at the regional level can reflect somewhat general trends, the results might not reflect exactly the true contributions to the growth in grain production.

2). The grain price information used in this paper might have bias. The grain prices derived from the exchange price ratios between respective agricultural products and salt, a key industrial product, were not actual prices, but price proxies.

If the change in the price of salt is the same as the change in the general price level in China, then these price proxies are more suitable, reflecting changes in real grain prices relative to other prices.

3). Because of the lack of information in some years for fertilizer, machinery and draft animals, some interpolations were involved. These interpolations may influence the estimated results.

4). Given the lack of input price data, the productivity analysis was based on the factor shares approach (geometric aggregation) rather than a Divisia - related approach.

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Appendix I Purchasing Price Indexes of Farm Products by Category of Commodity

Year	Grain	Rice	Wheat	Corn	Sorghum	Soybean
1950	100.0	100.0	100.0	100.0	100.0	100.0
1951	118.3	109.2	119.8	102.3	106.4	111.5
1952	121.4	115.2	123.4	108.4	122.2	112.5
1953	137.1	127.5	146.5	122.9	137.2	129.4
1954	137.1	127.3	146.5	123.1	137.4	130.9
1955	137.3	127.3	143.5	125.2	138.4	131.5
1956	139.9	129.3	143.1	127.7	144.9	134.6
1957	141.4	131.2	142.9	128.8	145.7	136.1
1958	145.1	133.8	143.2	138.6	154.7	142.9
1959	147.0	133.9	143.6	138.6	156.9	151.4
1960	151.7	137.9	146.8	143.2	158.5	176.2
1961	191.9	176.1	187.9	178.3	203.3	218.3
1962	192.4	177.5	187.9	180.4	203.3	218.7
1963	190.9	174.2	185.8	181.4	201.1	217.2
1964	189.2	174.2	185.8	181.8	200.9	217.2
1965	190.9	178.4	187.5	184.7	200.9	217.2
1966	220.8	203.2	215.2	218.4	235.4	253.2
1967	221.1	203.2	215.2	218.4	235.4	253.9
1968	221.1	203.2	215.2	218.4	235.4	253.9
1969	221.1	203.2	215.2	218.4	235.4	253.9
1970	221.1	203.2	215.2	218.4	235.4	253.9
1971	222.0	203.4	215.2	218.4	235.4	279.1
1972	222.2	203.4	215.2	218.4	235.4	279.1
1973	222.2	203.4	215.2	218.4	235.4	279.1
1974	222.4	204.2	215.2	218.4	235.4	279.1
1975	222.8	205.3	215.2	218.4	235.4	279.1
1976	222.8	205.3	215.2	218.4	235.4	279.1
1977	222.8	205.3	215.2	218.4	235.4	279.1
1978	224.4	205.3	215.2	218.4	235.4	348.0
1979	271.3	247.8	261.5	263.2	278.9	399.9
1980	271.8	248.0	261.8	263.5	279.2	410.3
1981	283.5	248.0	261.8	263.5	279.2	615.5
1982	283.5	248.0	261.8	263.5	279.2	616.1
1983	283.8	248.0	261.8	263.5	279.2	616.1
1984	282.4	247.7	261.8	263.5	279.2	560.0
1985	522.2	252.4	262.1	263.5	292.6	575.7
1986	573.9	268.3	273.4	310.1	376.3	692.0

Source: *Price and Trade Statistics in China*. P. 142.

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